Supplemental material

Title

Respiratory Health Effects of Exposure to "Low NOx" Unflued Gas Heaters in the Classroom: a Double-blind, Cluster Randomized Cross-over Study.

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Methods

Installation and control of heaters

The existing unflued gas heaters (Bowin mfg Pty Ltd, Sydney, Australia) were not serviced or modified except that an electric solenoid valve was fitted to allow remote operation. Also the existing blue cover was replaced with a white cover to match the color of the flued gas heater. In each classroom a Rinnai 1004FTR (37 MJ) or Rinnai 556FTR (23 MJ) flued gas heater was installed (Rinnai Australia, Braeside, Victoria, Australia). This is a flued gas convection heater with similar heating capacity to existing unflued heaters. The flued heater was installed as near as possible to the existing unflued heaters. In classrooms with two existing unflued gas heaters, two flued gas heaters were installed. The operation of each heater was controlled by a thermostat, which was moved to position outside the enclosure (see below).

A control box was installed in each classroom to allow the class teacher (or others) to turn the activated heater on or off, as desired at the beginning and end of each day and for comfort. The activated heater was selected by the key that could only be operated by NSW Public Works staff.

Blinding

To ensure that students, teachers and others in the classroom were not aware which heater was operating, the unflued heaters and flued heaters were placed inside a sight-proof louvered enclosure. The louvers were designed to be accessible, but capable of being secured. The enclosures were shown to have a negligible effect on the performance of the heaters or the gases produced. Where possible the adjacent flued and unflued heaters were placed with a single louvered enclosure. Where the class design did not allow this, separate enclosures were used.

Research staff were also kept blinded to the heater type allocation. Only NSW Public Works staff, who installed and activated the heaters, and one researcher who implemented the randomization and was not otherwise involved in the conduct of the study, were unblinded during the conduct of the study.

Randomization

We used an Excel spreadsheet with a random number generator to randomly assign the first week of each pair of weeks for each school to flued gas vs "low NOx" unflued gas heater type. The other week of the pair was assigned to alternative heater type. Each of the three pairs of weeks for each school was separately randomized. Schools were randomized in permuted blocks of four to ensure that there would be an equal number of schools in each group in every week.

An unblinded allocation was forwarded to NSW Public Works for implementation. A coded allocation was retained for analysis. Due to technical problems, the randomized order was reversed in one school for the first pair of week and the third pair of weeks and in another school for the first pair of weeks.

Measurement of indoor NO2 and formaldehyde concentrations

Airborne nitrogen dioxide (NO_2) concentrations in school classrooms were measured using passive diffusion badge monitors supplied by the CSIRO Division of Atmospheric Research. Formaldehyde samples were collected using UMEx 100 (SKC Inc., USA) passive sampling badges.

On Thursday and Friday of every week during the study period two NO_2 samplers were exposed at two different locations in each classroom. One formaldehyde sampler was co-located at one of these sites on both occasions. Samplers were attached to mounting plates and placed at levels of between 70cm and 110cm from the floor.

Sampler locations and time, date details were recorded. The sampling period was approximately 6 hours on each day during school hours. The height and exposure duration was selected to simulate the experience of a child sitting in the class throughout the school day.

Exposed samplers were forwarded to CSIRO Division of Atmospheric Research in Melbourne for NO_2 analysis and to WorkCover NSW who analysed the formaldehyde badges using High Performance Liquid Chromatography according to OSHA Method 64 modified. according to OSHA Method 64 Modified. All samplers were kept at < 4°C prior to and after use. NO_2 samples were sent with a blank control but formaldehyde badges incorporated a "blank correction" section so separate blanks were not required. All samplers were kept at < 4°C prior to and after use and transported on ice.

Supplemental Material Table E1

Effect of Heater type (Unflued gas heater– Flued gas heater) on lung function on subject-days on which the subject used bronchodilator in the morning or the evening

Population	FEV_1 AM (L)			FEV_1 PM (L)			PEF AM (L/min)			PEF PM (L/min)		
	difference	95% confidence interval	P	difference	95% confidence interval	P	difference	95% confidence interval	P	difference	95% confidence interval	P
intention to treat	**0.004**	-0.011 to 0.018	0.62	**0.001**	-0.014 to 0.017	0.85	**0.699**	-1.504 to 2.901	0.53	**1.332**	-0.830 to 3.494	0.23
Per protocol: days with heater use >= 30%	**0.032**	0.003 to 0.061	0.03	**0.014**	-0.018 to 0.046	0.39	**1.928**	-2.352 to 6.208	0.38	**6.130**	1.617 to 10.644	0.008

Population	FEV_1 AM (L)			FEV_1 PM (L)			PEF AM (L/min)			PEF PM (L/min)		
	difference	**95% confidence interval**	**P**	**difference**	**95% confidence interval**	**P**	**difference**	**95% confidence interval**	**P**	**difference**	**95% confidence interval**	**P**
asthma subgroup, ITT analysis	**-0.003**	-0.053 to 0.047	0.91	**-0.013**	-0.068 to 0.042	0.64	**2.038**	-7.597 to 11.673	0.68	**9.142**	0.773 to 17.511	0.03
asthma subgroup, PP analysis	**0.029**	-0.064 to 0.123	0.54	**-0.042**	-0.191 to 0.106	0.58	**-3.190**	-16.581 to 10.20	0.64	**15.730**	-6.197 to 37.656	0.16

Supplemental Material Table E2

Comparison of actual and long-term average temperatures in August and September 2009[a]

	Observed minimum	**Long-term average minimum**	**Observed maximum**	**Long-term average maximum**
Katoomba – August	5.4°C	3.2°C	14.5°C	11.1°C
Katoomba - September	7.0°C	5.3°C	16.8°C	14.4°C
Moss Vale – August	3.5°C	2.0°C	15.2°C	13.4°C
Moss Vale - September	6.0°C	4.0°C	17.6°C	16.5°C
Goulburn –August	1.3°C	2.2°C	14.8°C	13.2°C
Goulburn - September	3.4°C	4.5°C	17.1°C	16.5°C

a) Australian Bureau of Meteorology